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Indian Standard

SPECIFICATION FOR BOILER AND SUPERHEATER TUBES FOR MARINE AND NAVAL PURPOSES

(*First Revision*)

UDC 621·184·2/·3 : 669·14-462 : 629·12

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MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

Gr 5 *March* 1987

AMENDMENT NO. 1 AUGUST 1987

TO

IS:2416-1986 SPECIFICATION FOR BOILER AND SUPERHEATER TUBES FOR MARINE AND NAVAL PURPOSES

(*First Revision*)

(*Page* 6, *clause* 5.1) - Substitute the following for the existing clause:

"5.1 The tubes shall be manufactured from steel produced by open hearth, an electric arc or any of the oxygen processes. The chemical composition of each heat when analyzed shall comform to the following analysis:

Carbon - 0.08 to 0.25 percent

Manganese - 0.35 to 1.40 percent

Silicon - 0.35 percent, *Max*

Phosphorus - 0.050 percent, *Max*

Sulphur - 0.050 percent, *Max*

Steel produced by the oxygen process shall, in addition, contain not more than 0.009 percent nitrogen.

5.1.1 For alloy steels the trump elements shall be restricted to the following upper limits:

Copper - 0.25 percent

Tin - 0.03 percent

Nickel - 0.3 percent

Soluble aluminium - 0.02 percent

Chromium - 2.25 percent, *Max*

Molybdenum - 1.0 percent, *Max*

5.1.2 The permissible deviations from the specified chemical composition shall be as given in Table 1.

5.1.3 The analysis of steel shall be carried out either by the method specified in IS:228 'Methods for chemical analysis of steels' and its relevant parts or any other established instrumental/ chemical method. In case of dispute the procedure given in IS:228 and its relevant parts shall be referee method. However, where the method is not given in IS:228 and its relevant parts, the referee method shall be agreed to between the purchaser and the manufacturer."

(SMDC 22)

Reprography Unit, BIS, New Delhi, India

IS : 2416 - 1986

Indian Standard

SPECIFICATION FOR BOILER AND SUPERHEATER TUBES FOR MARINE AND NAVAL PURPOSES

(*First Revision*)

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(*Continued on page* 2)

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(*Continued on page* 17)

Indian Standard

SPECIFICATION FOR BOILER AND SUPERHEATER TUBES FOR MARINE AND NAVAL PURPOSES

(First Revision)

0. FOREWORD

0.1 This Indian Standard (First Revision) was adopted by the Indian Standards Institution on 24 April 1986, after the draft finalized by the Steel Tubes, Pipes and Fittings Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 This standard was published in 1963 and the revision of the standard has been prepared after reviewing the standard in the light of the experience gained by manufacturers and users in its usage. In this revision the manufacture of the product, the process of steel manufacture, steel designation and its chemical composition have been modified.

0.3 At the time of publication of IS : 1914 (Parts 1 to 4)-1982*, it was felt that this standard does not cover the special requirements regarding the close tolerance limits for outside diameter and thickness, minimum requirements of elongation test, and higher test pressures as applicable to tubes used for marine and naval purposes. Hence, it was decided that a separate standard for boiler and superheater tubes should be prepared. Further, this standard covers only carbon steel boiler and superheater tubes with minimum tensile strength of 320 MPa. But, wherever, the specialized nature of the naval requirements differs from the general mercantile shipping, these special requirements are separately included in Appendix A with suitable reference under relevant clauses.

0.4 In the preparation of this standard, the Committee kept in view the manufacturing and trade practices followed in the country in this field. Furthermore, due consideration has also been given to the need for international coordination with standards being followed in various

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*Specification for carbon steel boiler tubes and superheater tubes (*second revision*).

countries of the world. These considerations led the Committee to base this standard on:

a) Construction and Survey of Passenger Steamer Rules, 1956, Indian Merchant Shipping;
b) Schedule for Naval Stores Indian Navy;
c) BS 3059 : 1978 Steel boiler and superheater tubes, British Standards Institution;
d) Lloyds Register of Shipping; and
e) IS : 1914 (Parts 1 to 4)-1982 Specification for carbon steel boiler tubes and superheater tubes (*second revision*).

0.5 As the present practice is to base the design on the metal temperature instead of on the steam temperature, this standard relates to this basis of design. For convenience of reference the relation between metal temperature for different types is given below:

Types of Tubes	*Maximum Design Metal Temperature*
Economizer tubes	Maximum water temperature + 11°C
Furnace and boiler tubes	Saturation temperature of steam corresponding to design pressure 28°C
Convection superheater tubes	Maximum design steam temperature + 38°C.

0.6 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

0.7 This standard is intended chiefly to cover the technical provisions relating to the material, and it does not include all the necessary provisions of a contract.

1. SCOPE

1.1 This standard covers the requirements of the following types of boiler and superheater tubes for marine and naval purposes:

a) Cold finished seamless steel tubes,

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*Rules for rounding off numerical values (*revised*).

b) Hot finished seamless steel tubes,

c) Electric resistance and induction welded steel tubes, and

d) Cold finished ERW and induction welded steel tubes.

PART 1 GENERAL REQUIREMENTS

2. SUPPLY OF MATERIAL

2.1 General requirements relating to the supply and testing of material shall be as laid down in IS : 1387-1967*.

3. MANUFACTURE

3.1 Tubes shall be manufactured by one of the following processes:

CFS	—	Cold finished seamless	Part 2
HFS	—	Hot finished seamless	Part 3
ERW	—	Electric resistance welded and induction welded	Part 4
CEW	—	Cold finished electric resistance welded and induction welded	Part 4

a) *Seamless Tubes* — The tubes stall be manufactured by a seamless process and may be hot finished or cold finished.

b) *Welded Tubes* — The tubes shall be manufactured from either hot or cold rolled steel strip longitudinally welded continuously by the passage of an electric current across the abutting edges without the addition of filler metal.

3.2 The steel shall be produced by the open hearth, an electric arc or one of the basic oxygen processes.

3.3 The steel shall be fully killed except that for welded tubes it may be rimmed or semi-killed. Where the temperature is below 399°C, 'rimmed' or 'killed' steel may be used. If rimmed steel is used, the strips shall be rolled in single widths and not longitudinally.

4. DESIGNATION

4.1 The following grades of steels shall be used.

a) Carbon steels — Grades 310, 360 and 440

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*General requirements for the supply of metallurgical materials (*first revision*).

b) Ferritic alloy steels — Grade 460 to 560 and Grade 500 to 620

The tubes shall be designated by one of the references given for the method of manufacture, for example, hot finished seamless tubes made from grade 310 is 'HFS 310'.

5. CHEMICAL COMPOSITION

5.1 The tubes shall be manufactured from steel produced by open hearth, an electric arc or any of the oxygen processes. The chemical composition of each heat when analyzed in accordance with IS : 228[*] shall conform to the following analysis:

Carbon — 0·08 to 0·25 percent

Manganese — 0·35 to 1·40 percent

Silicon — 0·35 percent, *Max*

Phosphorus — 0·050 percent, *Max*

Sulphur — 0·050 percent, *Max*

Steel produced by the oxygen process shall, in addition, contain not more than 0·009 percent nitrogen.

5.1.1 For alloy steels the trump elements shall be restricted to the following upper limits:

Copper — 0·25 percent

Tin — 0·03 percent

Nickel — 0·3 percent

Soluble aluminium — 0·02 percent

Chromium — 2·25 percent, *Max*

Molybdenum — 1·0 percent, *Max*

5.1.2 The permissible deviations from the specified chemical composition shall be as given in Table 1.

6. WORKMANSHIP

6.1 The tubes shall be well finished, clean and free from harmful defects. The ends of the tubes shall be cut square. The tubes shall be reasonably straight, smooth and cylindrical. Surface marks and defects may be ground provided that the thickness of the tube after grinding is not less than the required minimum thickness. The grinded area shall blend into the contour of the tube.

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[*] Methods of chemical analysis of steels.

TABLE 1 PERMITTED DEVIATIONS FROM THE SPECIFIED CHEMICAL COMPOSITION

(*Clause* 5.1.2)

Element	Permissible Deviations from the Specified Chemical Composition on Product Analysis
Cr	+ 0·10
C	+ 0·03
Mn	± 0·10
S	+ 0·005
P	+ 0·005
Mo	+ 0·05

6.1.1 In case of electrically welded tubes (*see* Part 4) the external fin shall be removed completely, flush with the outside surface of the tube. For sizes above 32 mm OD the internal fin shall also be removed throughout the length of the tube, so that the maximum fin height does not exceed 0·25 mm. Elsewhere thickness tolerance (*see* **27.1**) shall apply.

NOTE — For sizes below 32 mm OD tubes the removal of internal fin shall be a subject of agreement between the purchaser and the manufacturer.

7. SELECTION OF TUBES FOR TESTING

7.1 Selection of Tubes for Testing — Two percent of the tubes of each thickness and diameter and only one for every 100 or part thereof above 400 tubes of such similar size shall be made available to the Inspecting Officer for testing to the extent of such numbers.

8. HEAT TREATMENT

8.1 Grades 310, 360 and 440 tubes in cold finished grades shall be subject to annealing/normalizing to a temperature range of 880 to 940°C.

For alloy steels the tubes in cold finished grades shall be subject to annealing normalizing to a temperature range of 900 to 960°C followed by tempering at a temperature of 650 to 750°C.

9. ADDITIONAL TESTS

9.1 Should a tube selected for testing fail in any one or more of the tests specified, two further tests of the same kind may be made on two other tubes from the same batch. Should either of these further tests fail, the batch of tubes represented may be heat-treated again and then retested for all tests, selecting the number of test pieces as given in **7.1**. If all the repeat tests are satisfactory, the tubes shall be deemed to comply with this standrad provided that they conform in all other respects with the requirement of this standard. But if failure again occurs, the batch of tubes which the test pieces represent shall be deemed not to comply with this standard.

10. TEST CERTIFICATE

10.1 In the test certificates, a statement of process of the manufacture of the steel and the test results shall also be furnished by the manufacturer.

11. CORROSION PROTECTION

11.1 The provisions for corrosion protection of boiler and superheater tubes shall be as agreed to between the manufacturer and the purchaser.

12. MARKING

12.1 Unless otherwise agreed to between the manufacturer and the purchaser, each tube shall be legibly stencilled with the name or brand of the manufacturer, the IS number and grade of the material. For tubes of diameter less than 48 mm, the above information should be marked on a tag securely attached to the bundle or box in which tubes are shipped.

12.2 The material may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.

13. INFORMATION TO BE SUPPLIED BY THE PURCHASER

13.1 The purchaser shall state the following in his enquiry and order:

a) The number and part of this Indian Standard;

b) Method of manufacture of tube and the grade of steel;

c) The tube dimensions, that is, outside diameter, thickness and length; and

d) The quantity in metres or numbers of lengths.

PART 2 SPECIFIC REQUIREMENTS FOR COLD FINISHED SEAMLESS STEEL TUBES

14. HEAT TREATMENT

14.1 The cold finished tubes shall be suitably heat-treated or normalized throughout their length.

14.2 When the ends of tubes, after heat treatment, are subjected to cold working operations, the ends shall be suitably heat-treated.

15. TOLERANCES

15.1 The thickness and outside diameter at any position, and the length of each tube shall be within the following tolerances:

Dimension	*Tolerance*
Thickness (*see* Note 1)	+ 10 percent − 5 percent
Outside diameter	+ 0 percent − 1 percent
Length:	
Up to and including 9 m	+ 3 mm
Over 9 m	+ 6 mm

NOTE 1 — Tubes ordered with swelled or reduced ends, shall be allowed an additional tolerance on thickness at the ends proportionate to the alteration in diameter of such swelling or reducing.

NOTE 2 — Special naval requirements are given in Appendix A.

16. TENSILE TEST

16.1 Tensile Strength — (a) The tensile strength of the material cut from finished tubes shall conform to one of the following five grades:

1) 31 to 41 kgf/mm^2,
2) 36 to 46 kgf/mm^2,
3) 41 to 51 kgf/mm^2,
4) 46 to 56 kgf/mm^2, and
5) 50 to 62 kgf/mm^2,

b) The upper yield point at room temperature shall not be less than 50 percent of the specified minimum tensile strength at room temperature.

c) The minimum values of the stress at proof limit 0·2 percent at elevated temperature (E_t) of the material may be calculated by multiplying the specified minimum tensile strength at room temperature (R 20) by the ratio (E_t/R 20) given in Table 2.

TABLE 2 MINIMUM VALUES FOR THE RATIO OF THE STRESS AT PROOF LIMIT 0·2 PERCENT AT ELEVATED TEMPERATURE (E_t) TO THE MINIMUM SPECIFIED TENSILE STRENGTH AT ROOM TEMPERATURE (R 20) OF CARBON-STEEL TUBES

Temperature	250°C	*275°C	300°C	325°C	350°C	375°C
E_t/R 20	0·40	0·38	0·36	0·34	0·33	0·32
Tempreature	400°C	425°C				
E_t/R 20	0·31	0·30				

*For temperature lower than 300°C any test required for acceptance purposes (in the absence of records of previous tests at the temperatures) shall be made at 300°C, in which case the proof stress shall be not less than the value obtained by calculation from the specified minimum tensile strength at room temperature and the ratio of 0·36 for 300°C.

d) The breaking elongation in percent shall be not less than

$$\frac{100 - R_m}{C}$$

where

$C = 2·2$ for only gauge length of $L = 5\,d_0$ or $5·65\sqrt{A_0}$,

d_0 = original diameter of the round test piece, and

A_o = original cross-section of the rectangular test piece.

17. FLATTENING TEST

17.1 A ring not less than 50 mm in length cut from one end of each selected tube shall be flattened between two parallel flat surfaces to a distance between the plates (H) as calculated by the formula given below without showing any sign of a crack or flaw.

$$H = \frac{(1 + C)\,a}{C + \dfrac{a}{D}}$$

where

a = thickness of tube (mm),

D = outside diameter of the tube (mm),

C = 0·09 for steel having a specified minimum tensile strength from 31 kgf/mm^2 up to and including 35 kgf/mm^2,

= 0·07 for steel having a specified minimum tensile strength over 35 kgf/mm^2 up to and including 42 kgf/mm^2,

= 0·05 for steel having a specified minimum tensile strength over 42 kgf/mm^2 up to and including 50 kgf/mm^2, and

= 0·03 for steel having a specified minimum tensile strength over 50 kgf/mm^2 up to and including 62 kgf/mm^2.

18. FLANGING AND DRIFT EXPANDING TESTS

18.1 a) The tube shall withstand either the flanging test or the drift expanding test at the option of the manufacturer.

b) *Flanging Test* — A test piece cut from the end of a tube in a plane perpendicular to the axis of the tube shall show no crack or flaw after flanging to the specified outside diameter as given in Table 3.

c) *Drift Expanding Test* — A test piece cut from the end of a tube in a plane perpendicular to the axis of the tube shall show no crack after expanding by a mandrel having an included angle of 30°, 45° or 60° at the option of the manufacturer to increase the outside diameter as given in Table 3.

TABLE 3 MINIMUM INCREASE OF OUTSIDE DIAMETER OF TUBES IN FLANGING AND DRIFT EXPANDING TEST

Type of Test	Minimum Specified Tensile Strength (s)	Outside Diameter (D) of the Tube	Increase of Outside Diameter of the Tube
	kgf/mm^2	$A = D < 63{\cdot}5$ mm $B = 63{\cdot}5 > D < 150$ mm	Percent
Flanging Test	$S < 42$	A	17
		B	11
	$S > 42$	A	14
		B	8
Drift Expanding Test		A	17
		B	11

19. HYDRAULIC TEST

19.1 Each tube shall be tested at the manufacturer's works on completion of manufacture and shall withstand a hydraulic pressure to one and half times the design pressure subject to a minimum of 7 MPa (70 kgf/mm^2) but not greater than the pressure calculated by the following formula:

$$P = \frac{2\,St}{D}$$

where

P = test pressure,
D = outside diameter of the tube,
t = nominal wall thickness of the tube, and
S = stress which shall be taken as 40 percent of the minimum tensile strength at room temperature.

NOTE — The time for holding the test pressure shall be 5 seconds.

19.1.1 Such requirements as covered by test pressure higher than those specified, shall be subject to mutual agreement between the manufacturer and the purchaser.

NOTE — Special naval requirements are given in Appendix A.

PART 3 SPECIFIC REQUIREMENTS FOR HOT FINISHED SEAMLESS STEEL TUBES

20. HEAT TREATMENT

20.1 Hot finished seamless tubes shall be supplied in hot finished condition. At the option of the manufacturer these tubes may be annealed or normalized. If any cold working is carried out at the ends of the tubes, the ends may be suitably heat-treated to remove the stresses.

21. TOLERANCES

21.1 The thickness and outside diameter at any position, and the length of each tube, shall be within the following tolerances:

Dimension	*Tolerance*
Thickness	+ 17·5 percent − 7·5 percent
All sizes (*see* Note)	
Outside diameter	
up to and including 63 mm	+ 0·4 mm − 0·8 mm
Over 63 mm	± 1 percent

NOTE — Tubes ordered with swelled or reduced ends shall be allowed an additional tolerance on thickness at the ends, proportionate to the alteration in diameter of such swelling or reducing.

22. TENSILE TEST

22.1 See details of tensile strength, as given in **16.1** of Part 2 in this standard.

23. FLATTENING TEST

23.1 See details of flattening test as given in **17.1** of Part 2 in this standard.

24. FLANGING AND DRIFT EXPANDING TEST

24.1 See details of flanging and drift expanding test as given in **18.1** of Part 2 in this standard.

25. HYDRAULIC TEST

25.1 See details of hydraulic test as given in **19.1** of Part 2 in this standard.

PART 4 SPECIFIC REQUIREMENTS OF ELECTRIC RESISTANCE WELDED/INDUCTION WELDED STEEL TUBES AND COLD FINISHED ELECTRIC RESISTANCE WELDED/INDUCTION WELDED STEEL TUBES

(Alloy steel grades are not included)

26. HEAT TREATMENT

26.1 The tubes shall be normalized throughout their length.

26.1.1 When the ends of tubes, after heat treatment, are subjected to cold working operations, the ends shall be suitably annealed.

27. TOLERANCES

27.1 The thickness and outside diameter at any position, and the length of each tube shall be within the following tolerances:

Dimension	*Tolerance*
Thickness (*see* Note)	+ 10 percent – 5 percent } excluding welds (*see* **6.1.1**)
Outside diameter	+ 0·75 percent with a minimum of 0·3 mm

Length:

Up to and including 9 m	+ 3 mm − 0 mm
Over 9 m	+ 6 mm − 0 mm

NOTE — Tubes ordered with swelled or reduced ends shall be allowed an additional tolerance on thickness at the ends proportionate to the percentage alteration in diameter of such swelling or reducing.

28. TENSILE TEST

28.1 See details of tensile strength as given in **16.1** of Part 2 in this standard.

29. FLATTENING TEST

29.1 See details of flattening test as given in **17.1** of Part 2 in this standard.

30. FLANGING AND DRIFT EXPANDING TEST

30.1 See details of flanging and drift expanding test as given in **18.1** of Part 2 in this standard.

31. HYDRAULIC TEST

31.1 See details of hydraulic test as given in **19.1** of Part 2 in this standard.

32. ULTRASONIC TEST

32.1 For welded tubes, ultrasonic or any equivalent testing methods shall be used for the continuous examination of the weld area. This examination is made for the purpose of quality control during the process of manufacture by a method and at a place chosen by the manufacturer.

APPENDIX A

(*Clauses* 0.3, 15.1 *and* 19.1.1)

NAVAL REQUIREMENTS

A-1. REQUIREMENTS

A-1.0 For the purpose of meeting certain special naval requirements, the following tolerances and tests shall apply in place of the corresponding provisions specified in this standard, subject to the mutual agreement.

A-1.1 In place of **15.1**

The thickness and outside diameter at any position, and the length of each tube shall be within the following tolerances:

Dimension	*Tolerance*
Thickness (*see* Note)	+ 10 percent – 2·5 percent
Outside diameter:	
Up to and including 32 mm	+ 0·18 mm – 0·00 mm
Over 32 mm up to and including 50 mm	+ 0·25 mm – 0·00 mm
Over 50 mm	+ 0·38 mm – 0·00 mm
Length:	
Up to and including 9 m	+ 3 mm – 0 mm
Over 9 m	+ 6 mm – 0 mm

NOTE — Tubes ordered with swelled or reduced ends shall be allowed an additional tolerance on thickness at the ends, proportionate to the alteration in diameter of such swelling or reducing.

A-1.2 In place of **18.1**

The ends of tubes shall withstand being expanded cold to a length of 35 mm by three roller expander to the following increase of diameter without cracking:

Thickness of Tubes mm	*Increase in Diameter* percent
Under 3·2	12·5
3·2 to 5·0	9·5
Over 5·0	6·5

A-1.3 In place of **19.1**

Each tube which satisfactorily passes all tests will be tested internally by water pressure as given below:

External Diameter of Tube mm	*Water Pressure* MPa
50 and below	17·25
Above 50	10·30

This test is to be made after the tube is completed and no permanent alteration of form or any indication of weeping takes place.

A-1.4 In place of **18.1**

The ends of tubes shall withstand being expanded cold by three roller expander to the following increase of diameter without cracking.

Thickness of Tubes mm	*Increase in Diameter* percent
5·0 and thinner	15
Thicker than 5·0 up to and including 6·3	12
Thicker than 6·3	9·5

(*Continued from page* 2)

Panel for Revision of IS : 1914, IS : 3609 and IS : 2416 SMDC 22/P-18

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Shri H. J. Thaker	Gujarat Steel Tubes Ltd, Ahmadabad

INTERNATIONAL SYSTEM OF UNITS (SI UNITS)

Base Units

QUANTITY	UNIT	SYMBOL
Length	metre	m
Mass	kilogram	kg
Time	second	s
Electric current	ampere	A
Thermodynamic temperature	kelvin	K
Luminous intensity	candela	cd
Amount of substance	mole	mol

Supplementary Units

QUANTITY	UNIT	SYMBOL
Plane angle	radian	rad
Solid angle	steradian	sr

Derived Units

QUANTITY	UNIT	SYMBOL	DEFINITION
Force	newton	N	1 N = 1 kg.m/s^2
Energy	joule	J	1 J = 1 N.m
Power	watt	W	1 W = 1 J/s
Flux	weber	Wb	1 Wb = 1 V.s
Flux density	tesla	T	1 T = 1 Wb/m^2
Frequency	hertz	Hz	1 Hz = 1 c/s (s^{-1})
Electric conductance	siemens	S	1 S = 1 A/V
Electromotive force	volt	V	1 V = 1 W/A
Pressure, stress	pascal	Pa	1 Pa = 1 N/m^2

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